PUTTING RESEARCH TO WORK BRIEF

Promising Bridge Pile Strength Test Won't Work in Shorter Time Frames

Most bridges in Wisconsin are supported by columns, or piles, that are driven into the soil beneath the bridge. It is known that piles typically gain load-bearing strength over time; this increase in strength is called set-up, and varies according to the type of soil in which a pile is embedded. If pile set-up could be accurately predicted in the design stage, bridge designers could potentially use smaller pile sections or shorter pile lengths and still feel confident in the bridge's load-bearing capacity. A reduction in pile size could lead to savings in material and equipment costs, if lighter equipment could be used to drive the smaller piles.

The most accurate method of estimating long-term pile set-up is through project-specific pile testing, in which a limited number of piles are installed and subjected to dynamic monitoring and/or static testing. This is time-consuming and not cost-effective or feasible for most projects.

In a previous study, Project 0092-00-14, "Estimating Soil/Pile Set-Up" (see http://www.dot.wisconsin.gov/library/research/reports/geotechnics.htm), investigators identified and analyzed methods for estimating set-up and recommended the Standard Penetration Test-Torque test as the most promising pile set-up estimation method for relatively short time frames. The SPT-T test involves applying torque to a split-barrel sampler after penetration, and measuring the resulting sampler rotation. The measured torque is then compared to sampler rotation to determine soil/sampler shaft resistance. When the sampler is re-torqued after a time interval, the rate and magnitude of the increase in soil/sampler resistance (set-up) can be determined, and correlated to long-term pile set-up values.

Since the SPT-T test uses common subsurface exploration equipment, it was anticipated that it could be incorporated into routine subsurface exploration programs.

What's the Problem?

While some research has correlated the results of SPT-T tests to measured long-term pile set-up, such data is limited, and no research has involved Wisconsin soils. Moreover, test intervals in previous studies ranged from several hours to several weeks, too long for inclusion in routine WisDOT subsurface exploration programs. For the SPT-T test to become a viable tool for predicting pile set-up, correlations would need to be observed for short-term (one hour or less) time intervals in Wisconsin soils.

Research Objectives

This study sought to evaluate the effectiveness of using the SPT-T test as a soil/pile set-up estimation method within WisDOT's typical subsurface exploration time frames. Secondary objectives included developing accurate, rugged and sufficiently sensitive SPT-T testing equipment, and identifying the effect of staging and time variables on test results.

Methodology

Researchers selected a test site in the Marquette Interchange construction site in downtown Milwaukee, south of Interstate 794 and west of North 2nd Street. They aimed to assess correlations between short-term pile set-up data from SPT-T tests and long-term set-up data from extensive pile testing that had been conducted nearby as part of the interchange design. The thick, relatively uniform soil strata underlying the site also was a factor in test site selection.

The SPT-T tests were conducted at 21 sample depths in three major soil types—organic silt, silty clay and sand. Test intervals ranged from 4 minutes to overnight (approximately 1,000 minutes).

The test schedule also investigated the influence of split-barrel sampler soil recovery and test staging on SPT-T results. To this end, SPT-T testing incorporated both plugged and unplugged split-barrel samplers, and both staged (multiple time-interval tests at a single test depth) and unstaged (one time-

Investigator

"We did not find a relationship between the result of short-term SPT-T testing and soil/pile set-up."

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The SPT-T test equipment, which mounts on a drill rig, held promise as a short-term method for estimating long-term soil/pile set-up. However, this research showed that SPT-T tests do not appear to accurately predict set-up within the time frames required for routine, economical subsurface investigations.

interval test at a single test depth) testing.

Researchers compared the results of the SPT-T tests with long-term set-up results obtained at the adjacent pile test site, and analyzed whether sampler recovery or staged testing affected SPT-T test results.

Results

No reasonable correlation was observed between short-term SPT-T test data and long-term set-up measured at the adjacent pile test site. Therefore, researchers concluded that short-term SPT-T testing does not appear to be a practical, economical method for predicting pile set-up during routine WisDOT subsurface exploration programs. Additional results include:

- SPT-T set-up in cohesive soils was typically lower than in organic or granular soils.
- Twelve pile tests showed set-up over the first two hours; nine tests showed relaxation.
- Data obtained from staged testing indicated negative set-up (relaxation) over the first 15 minutes, followed by positive set-up.
- Data obtained from tests comparing plugged and unplugged samplers suggests that sampler recovery likely impacts test results. Staged and unstaged SPT-T testing appeared to produce similar test results.

As a secondary objective of this project, researchers and WisDOT staff were successful in jointly developing SPT-T test and data collection equipment that provided a more constant rate of torque application, and better electronic monitoring of both torque and rotation, than equipment used in previously published studies.

Benefits

Although the SPT-T test seemed to be a promising new tool for short-term set-up estimation, this research demonstrated that the test does not appear to accurately predict set-up within time intervals required for routine, economical subsurface exploration programs. Therefore, WisDOT can eliminate the SPT-T test from consideration as a set-up prediction tool.

This brief summarizes Project 0092-04-09, "Investigation of Standard Penetration Torque Testing (SPT-T) to Predict Pile Performance," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research, Development & Technology Transfer Program, 4802 Sheboygan Ave., Madison, WI 53707.

Nina McLawhorn, Research Administrator

Project Manager

"I wish the results had been different, but I'm glad we were able to rule out the SPT-T test as a method of estimating set-up."

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